THE POPULATIONS OF FISHES AND LIMNOLOGICAL CONDITIONS OF HEYBURN RESERVOIR WITH REFERENCE TO PRODUCTIVITY

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1952

Submitted to the faculty of the Graduate School of
Oklahoma State University in partial fulfillment
of the requirements for the degree of
DOCTOR OF PHILOSOPHY
May, 1958

THE POPULATIONS OF FISHES AND LIMNOLOGICAL CONDITIONS OF
HEYBURN RESERVOIR WITH REFERENCE TO PRODUCTIVITY

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PREFACE

The environment for populations of fishes in new reservoirs usually is favorable for good growth of fishes during the early years of impoundment. In Heyburn Reservoir the characteristic early "bloom" of productivity lasted only through the first two summers. At the outset of the third growing season, the reservoir became turbid and the condition persisted throughout the study period. It seemed quite apparent that the turbidity, from suspended soil particles, was largely responsible for the low population level and poor growth rate of fishes in the reservoir.

I wish to express my indebtedness to all those who gave assistance during this investigation. Special thanks are extended to my adviser, Dr. W. H. Irwin, for his patient assistance and advice. I wish to thank committee members Drs. Featherly, Howell, Jones, and Moore for their suggestions. I would also thank Dr. Homer Buck for giving supplemental data, Mr. W. H. Thompson for cooperation and a large group of friends and fellow students who assisted in collecting the data.

Financial assistance was provided by the Oklahoma Fish and Game Council.

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CHAPTER I

INTRODUCTION

Data on conditions relative to populations of fishes, limnological and general productivity conditions of Herburn Reservoir, a small flood-control impoundment (1070 acres) on Polecat Creek, Creek County, Oklahoma are presented herein. The collection of data concerning fish populations and limnological conditions began in late summer (August 1 to September 10) 1952, two years after initial water storage, and continued through the summer of 1953.

Factors influencing the selection of Heyburn Reservoir for study included its location which is within 20 miles of the cities of Tulsa, Sapulpa, Bristow, Sand Springs and Drumright; therefore, it should have been subjected to heavy fishing pressure. With that in mind, in the planning of the thesis, creel census data were to have been an important part of the study, for it was assumed that Heyburn would follow the usual pattern of high original reservoir productivity. A gradual decline in productivity which occurs consistently on man-made lakes was greatly accelerated in Heyburn Reservoir. Early in the study it became evident, from the rapid decrease of fishing pressure, that emphasis must be shifted and, thereafter, considerations were primarily of the fish populations, limnological factors and conditions of productivity. Permanent soil turbidity persisted throughout the study period and moderate productivity was short-lived.

Some of the factors that seemed to be largely responsible for the initial mediocre success of the fish population and the early decline of growth rates of fishes in Heyburn Reservoir were low soil fertility, softness of the water and high soil turbidity. Numerous articles have been written concerning the improvement of productivity in small impoundments by the addition of organic matter (Irwin and Stevenson, 1951; Swingle and Smith, 1942; Dobie, 1955). Degrees of productivity have been restored to reservoirs by draining, growing crops of vegetation on the exposed bottoms and refilling (Irwin, 1948; Aldrich, 1946; Langlois, 1946; Dobie, 1955). The problems of managing man-made impoundments have received much attention during the past decade. Thompson (1954) reviewed some of the considerations of management of reservoirs in the southwestern United States and noted that public resistance is a principal impediment to better management.

CHAPTER II

THE RESERVOIR AND WATERSHED

Heyburn Reservoir, located on Polecat Creek, Creek County, Oklahoma, was authorized by Congress principally to provide flood protection for the Polecat Creek Valley and for reduction of flooding in the Arkansas River Basin. Water impoundment to conservation pool level was completed in June, 1950. The dam site is about nine miles northeast of Bristow and eleven miles west of Sapulpa, Oklahoma. Information concerning the elevations and areas are given in Table I.

Polecat Creek Basin, oval in shape, is about 33 miles long, has a maximum width of about 20 miles, and contains approximately 350 square miles, of which 127 are above the dam site. The geological formations underlying the surface of the basin are sandstones and shales with occasional beds of limestone. Rock outcroppings are limited primarily to the sides of the valleys. Surface soils of the watershed consist of sandy loams and sandy stoney loams of brownish and reddish color. Specifically, the upland types are of Conway and Hanceville fine sandy loam and rough stoney land (Hanceville soil material). The soils of the bottom lands are fine alluvial loams, light brown in color, consisting of Verdigris fine sandy loam, Bates fine sandy loam, Parsons clay loam, and Miller silty clay loam (Anon., 1950). The watershed lies in an area largely covered by a forest of scrub oak. The terrain is hilly to gently rolling and the slopes are generally uniform, covered largely by post oak and black-jack oak. The more open areas support vegetation consisting largely of native grasses. A large percentage of the bottom land is in cultivation.

Polecat Creek flows from near Drumright (elevation 1000 feet) in a southeasterly direction for 37 miles, thence northeast for 21 miles, then east 12 miles to empty into the Arkansas River (elevation 600 feet). The stream slopes 12.7 feet per mile in the vicinity of the Heyburn Dam Site. The lake, at conservation pool level, is about one-half mile wide at the dam site, and extends about six miles up Polecat Creek and about two miles up Brown's Creek, a branch which joins Polecat Creek just above the dam.

TABLE I

Elevation, areas, and storages of Heyburn Reservoir (Anon. 1950)

Features	Elevation	Acres	Capacity (acre-feet)
Top of dam	807.0*		
Top of flood control pool	784.0	3,700	59,700
Top of conservation pool	761.5	1,070	10,200
Shore line at 761.5, 40 miles			

*Elevations refer to height above mean sea level.

Climate

Rainfall has averaged 37.31 inches per year over a 20-year period. Approximately 63 percent occurs during the period of April to September with May and June having the highest averages (4.59 and 4.69 inches respectively). The air temperature averages over an 18-year period (1930 to 1948) were from 38° F. in January to 82° F. in July, the range being from -18° F. to 115° F. The average growing season is 217 days extending from March 30 to November 2. The temperature and precipitation records have been kept at a U. S. Weather Bureau Station in Bristow, Oklahoma, 11 miles south of the dam site.

CHAPTER III

METHODS

Collections of fish were made by means of rotenone, wire traps, gill nets, seines and hoop nets. The traps and nets were those used in the study of Canton Reservoir (Buck and Cross, 1951). Intensive trapping was done in all types of habitats discernible. Most of the sets, however, were made in areas where fish might be concentrated, as around submerged brush piles and along brushy rocky banks. Traps and nets were inspected daily during week days and left unmolested over the weekends, because, the large number of pleasure seeking visitors made fish collecting inconvenient. The week ends were spent largely in collecting creel census data, particularly during August and September of 1952. There were relatively few fishermen during the summer of 1953 and fishing success was poor.

Gill Nets

Gill nets were not used extensively because of the inconvenience of operation by one person. The gill nets used were 175 feet long, eight feet deep and with two-inch mesh, bar measurement. Most commonly sets were made across coves and upper arms which were narrow enough to be spanned by a net. Sets in the open water were made perpendicular to the shore with the nets attached to the bank and anchored to the lake bottom.

Hoop Nets

Hoop nets were the "O" type, one-inch mesh, with 10-foot wings and a 60-foot lead. The leads were seldom used because of the difficulty of setting them single-handed. Sets were usually made along shore lines or in small coves. Anchors, to keep the net in position, were made of No. 2 cans filled with concrete. Markers were not used because of the possibility of tampering by sightseers and fishermen on the lake. Nets were located for inspection by grappling which occasionally required considerable time. In gneral, hoop nets were more effective than gill nets.

Tangle Nets

Tangle nets were used intensively through the week of July 20 to 25, 1953. The nets, made of fine nylon thread (No. 139), were of various lengths (50 to 175 feet), 12 feet in depth with meshes of three and one-half and four inches, bar measurement. Neither floats nor lead lines were used on the tangle net. The set was made by securing both ends of the supporting line to some object and the net allowed to hang loosely in the water. The net exhibits efficient entangling ability. Flathead catfish and various turtles were the principal species taken.

Seines

Seining was done occasionally to check for young-of-year of the various species of game and rough fish and to determine the kinds of minnows. The seine used was a 10-foot, 0.25-inch knotted-mesh minnow seine.

Eradication

Powdered cubé root, containing five percent rotenone, and "fishtox," a special preparation containing rotenone, were used in the sampling of four coves. More data were collected in this way than by means of all other methods combined. On July 9 and 11, 1953, four coves totaling 51 acre feet were sampled. The coves were treated with rotenone at the rate of 1.5 parts per million. Approximately 250 pounds of cubé root were used. Treating was accomplished by dragging burlap bags, partly filled with the toxicant, behind boats. The equipment used was furnished by the State Game and Fish Department, Corps of Army Engineers and Oklahoma State University. Personnel included members of the State Game and Fish Commission, Corps of Army Engineers and a class of fisheries biology students from Oklahoma State University. During the last week of July, 1953, one of the coves, that had been treated six weeks earlier, was treated again primarily to see what fish had reoccupied the cove. Also, during that month, a few small areas in the mouths of creeks that emptied into the lake were poisoned with rotenone. These small areas, each requiring a pound or less of cubé root, were sampled in search for young-of-year and for information concerning the minnow populations.

Creel Census

Creel census data were collected at Heyburn Reservoir by the writer and Army Engineer personnel of the Heyburn Project. Because of the many access points to the lake, some of the better anglers were not contacted. Many of them made a practice of visiting the upper bays at times when creel census takers were absent. Also, some of the personnel collecting data at times estimated the numbers of the fishermen and of the catch, thereby further reducing the reliability of the data. The writer collected creel census data during August, 1952, and June and July, 1953. Fishing pressure, during both periods, was low, but particularly so during June and July of 1953. The most accurate item of information shown by the creel census was that the channel catfish averaged highest in pounds harvested.

<u>Recording Data</u>

All fish captured were examined while fresh, many while alive. Minnows and specimens of young-of-year were fixed in a 10-percent formalin solution and later stored in 70-percent alcohol. During the months of August and September, 1952, when trapping was carried on intensively, the usual field procedure was to carry balances, fishboard, scale envelopes and notebook in the boat. The procedure of gathering fish data as the fishes were taken from the traps was feasible because the average daily catch was only 18 fish. The species from each catch were sorted and the following data recorded. Weights were recorded to the nearest one-hundredth of a pound and the total lengths were recorded to the nearest tenth of an inch. Occasionally the larger bass, crappie and channel catfish were checked for stomach contents and sex. Scale samples were collected from the scaled fishes and pectoral spines from catfish for age and growth determinations. Somewhat different methods were used for collecting and recording data from rotenone sampling. Previous samples indicated the presence of dominant size groups in some species (1950 year-class of white crappie, five to seven inches in length). A sample of 20 specimens from each inch-range was taken from the few groups which appeared in larger numbers. Because of the relatively large area (51 acre feet) of water sampled by rotenone, the catch of some species was too large to count; these species were ranked by order of abundance and estimates were made of total numbers and percentages of total numbers of a species taken.

TABLE II

A comparison of rotenone and trap methods with the species taken and their percentage of abundance

Rotenone		Traps and Nets	
Species Taken	Percentage of Total	Species Taken	Percentage of Total
Gizzard shad	39.6	Crappie	43.3
Green sunfish	17.2	Bullhead	22.5
Bullhead	12.5	Channel catfish	13.2
Orangespotted and Longear sunfish	14.3	Green sunfish	5.6
Crappie	8.7	Bluegill	4.4
Bluegill	5.5	Carpsucker	3.4
Channel Catfish	2.2	Largemouth bass	3.3
Carpsucker	1.8	Orangespotted and Longear sunfish	2.1
Largemouth bass	.8	Redear sunfish	1.2
Flathead catfish	.5	Gizzard shad	1.2
Redear sunfish	.1	Carp	.8

Collections

The four coves poisoned (Figure 1) were selected for size, shape, accessibility, shore line and wind exposure. A gill net was set across the mouth of each cove to help prevent ingress or egress of fishes.

The first cove treated, hereafter referred to as Cove I, was the largest, estimated at 14 acre feet. The banks were steep and rocky with black-jack oak forest on both sides of the cove. Approximately 60 pounds of fishtox were used. Collection of fish began about 30 minutes after application of the poison, the gizzard shad typically making the first appearance. It was believed that the amount of toxicant was insufficient, but when an additional 20 pounds were added, no additional effect was evident. The fishes were collected with dip nets and transferred to containers, then later brought to the weighing station. Weights and lengths were recorded, scale samples taken, and the fishes were sorted into species.

The second, Cove II, the smallest, was estimated to contain four acre feet of water; its banks also were wooded, rocky and steep. Fifteen pounds of fishtox were used and as in Cove I, the number of fish taken was fewer than expected. Coves I and II were treated on June 9, and Coves III and IV on June 11.

Cove III, about 10 acre feet, was shallow with no water deeper than 10 feet. The low grassy banks were free of trees, except for occasional small willows. Forty-seven largemouth bass that averaged fourteen inches in length and weighed two pounds or more each were recovered from the cove. The fish were in good condition and were all of the 1950 year-class. The young-of-year of bass, crappie and shad were not found in the first poisoning of any of the four coves.

Selectivity of Sampling Methods

Since there is no method capable of sampling accurately and infallibly all sizes and species of fishes, the available devices must be used to the best advantage. The use of rotenone produced the best results in giving the greatest number of individuals (Table II) and greatest variety of species. It thereby may be presumed to reflect most nearly the true population proportions within the lake. Wire traps were second to rotenone in numbers of fishes collected. The young-of-year were absent

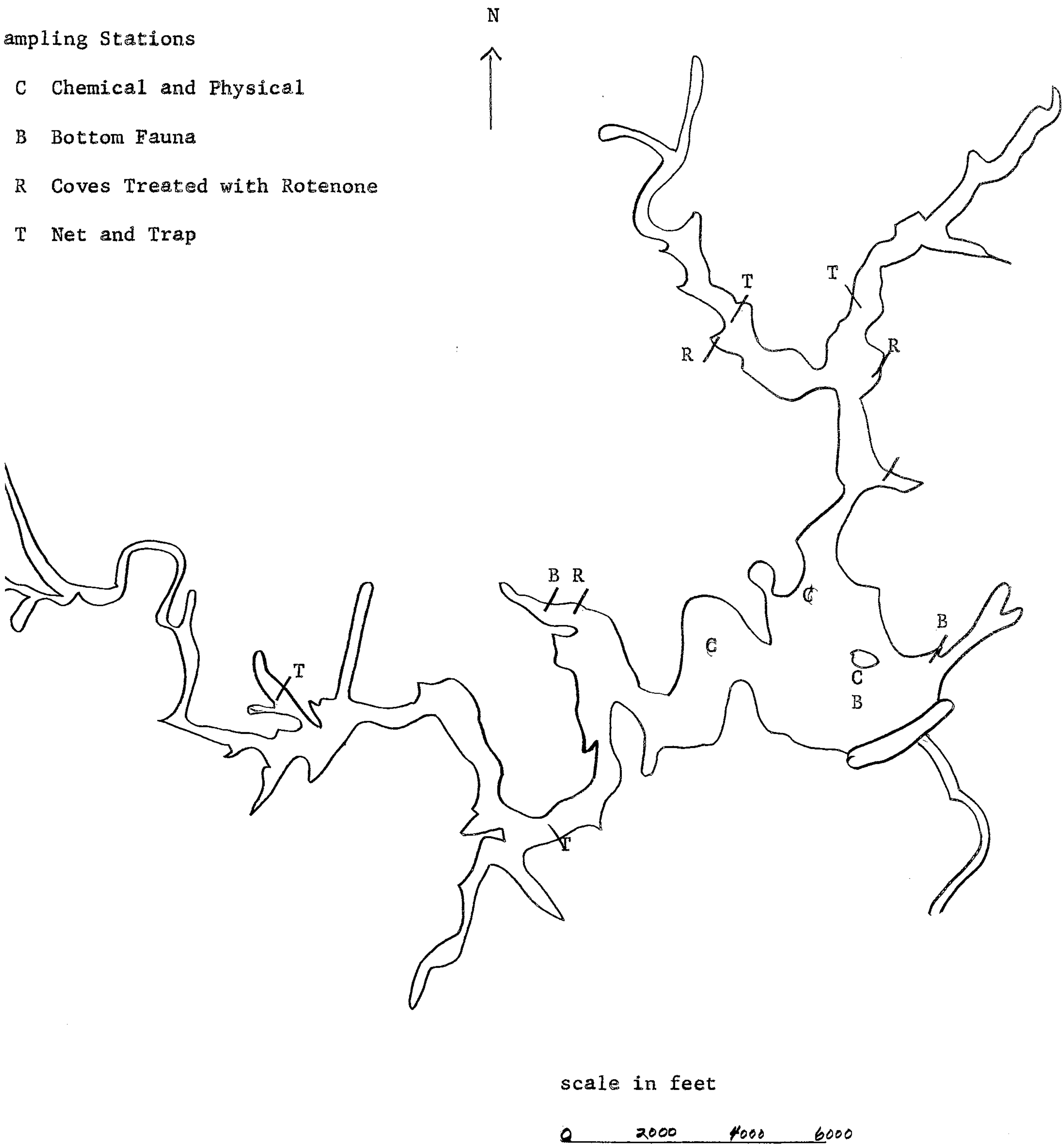

Figure 1 - Heyburn Reservoir with various sampling stations shown.

in the catch of nets and traps. It seems that the young would have been too small to be captured in the one-inch-mesh gear. The two young-of-year bass that were caught July 25, 1953, weighed only .0034 of a pound each; obviously, these small fish could not be held by one-inch mesh.

It would seem that the large crappies were the only size group not collected by the use of rotenone. While trapping and netting during August and September of 1952, two large crappie were taken in a wire trap. The fish were twelve inches long and weighed one and one-half pounds; creel census data were collected from two other such crappie. Large crappies did not appear in the collections or creel census for 1953. It was thought that the larger crappies had escaped by moving to deeper water before rotenone was applied. Few largemouth bass were taken in traps. The average was two fish per week during the 1952 collecting period. The rotenone method did not show the four- to seven-inch crappie to be present in as large numbers as the trapping collection suggested. Small crappies composed forty-three percent of all fish taken in traps, but they composed less than ten percent of the total fishes taken by the use of rotenone. The foregoing instances are considered in subsequent discussions of the species mentioned, but the various examples of selectivity are worthy of note. Table III contains a record of the fishes stocked in the reservoir.

TABLE III

Species and number of hatchery-reared fish stocked in Heyburn Reservoir

Species	No. Fish	Date Stocked	Size
Largemouth bass	7,560	9-24-50	Fingerling
Largemouth bass	2,500	11-16-50	Fingerling
Largemouth bass	21,000	3-16-51	Fingerling
Total	31,060		
Black crappie	4,000	11-16-50	Fingerling
Total	4,000		
Channel catfish	4,500	9-24-50	Fingerling
Channel catfish	4,500	12-1-50	Fingerling
Total	9,000		
Redear sunfish	10,000	11-16-51	Fingerling
Redear sunfish	26,000	3-16-51	Fingerling
Total	36,000		
GRAND TOTAL	80,060		

CHAPTER IV

ANNOTATED LIST OF SPECIES PRESENT

The list of species is compiled from data collected from Heyburn Reservoir during August and September, 1952, and June and July of 1953. The systematic sequence of fishes included in the list follows that given in the unpublished, Keys to Oklahoma Fishes by Dr. George A. Moore, Oklahoma State University. Species names appearing without discussion will be considered elsewhere in the thesis.

1. *Lepisosteus productus* (Cope)

Spotted gar, four in number, each about eighteen inches long, were taken from Cove IV following rotenone treatment. Lagler, Obrecht and Harry (1942) hypothesized that gar populations are useful where large populations of forage fish occur. The predatory influence of gar in Heyburn could not be considered important on the basis of the apparent populations of either gar or forage fishes. The specimens were identified as *L. productus* on the basis of lateral-line scale count, 56 in one and 57 in three, and general body depth which was considerably deeper through the midsection than through the occipital region.

2. *Dorosoma cepedianum* (Le Sueur)
3. *Carpiodes carpio carpio* (Rafinesque)
4. *Cyprinus carpio* (Linnaeus)
5. *Notemigonus crysoleucas* (Mitchell)

Only two specimens were captured. They were taken in Cove I by means of rotenone; both specimens were about four inches long. The golden shiner may have been introduced by users of bait monnows or may have been in the creek before impoundment. There is no record of stocking for the species.

6. Notropis lutrensis lutrensis (Baird and Girard)

The red shiner was the most abundant minnow species in the lake. Their numbers were not great; only about 90 specimens were collected. It is doubtful if the species was present in numbers great enough to add much forage for large fishes.

7. Pimephales promelas (Rafinesque)

Only a few (20) fathead minnows were collected; their role in Heyburn could only be a minor one.

8. Pimephales notatus (Rafinesque)

The bluntnose minnow, like the fathead, were few in number (60) though somewhat more common than P. promelas or P. vigilax.

9. Pimephales vigilax (Girard)

Only 25 specimens of the bullhead minnow were collected.

10. Ictalurus punctatus (Rafinesque)

11. Ictalurus melas (Girard)

The black bullhead catfish was common in the reservoir, appearing second most frequently in trapping and third in rotenoning. The compact schools of young-of-year were observed on several occasions.

12. Ictalurus natalis (Le Sueur)

The yellow bullhead catfish, while less common than the black bullhead, was found frequently. Both species are discusses elsewhere under "bullheads."

13. Pylodictis olivaris (Rafinesque)

14. *Fundulus kansae* Garman

The plains killifish was found in pools far up the arms of the lake. About 70 specimens appeared in the collections. Poisoning of the small tributary pools with rotenone was the means of capture.

15. *Fundulus notatus* (Rafinesque)

The blackstripe top minnow was scarce. Fewer than 20 individuals were captured.

16. *Gambusia affinis* affinis (Baird and Girard)

The mosquito fish was not numerous. About 80 specimens were taken.

17. *Micropterus salmoides* (Lacépède)

18. *Lepomis cyanellus* (Rafinesque)

19. *Lepomis megalotis* (Rafinesque)

Longear sunfish are discussed, with orangespotted sunfish as "miscellaneous sunfish," in a later section of the paper.

20. *Lepomis macrochirus macrochirus* (Rafinesque)

21. *Lepomis microlophus* (Günther)

22. *Lepomis humilis* (Girard)

23. *Pomoxis annularis* (Rafinesque)

24. *Pomoxis nigromaculatus* (Le Sueur)

25. *Chaenobryttus coronarius* (Bartram)

Two small specimens of warmouth bass were captured by the use of rotenone from Cove I. The smallest specimen, year-class I, was 2.3 inches in length and weighed 0.01 pounds. The larger of the two, year-class II, was 4.4 inches in length and weighed 0.07 pounds. Growth comparison of warmouth bass from other lakes shows the Heyburn Reservoir specimens to be below the poorest as shown by Carlander (1953). Poor growth of warmouth was found in Onized Lake, Illinois, 2.9 and 4.9 inches for I and II year-classes respectively. In the Wister, Oklahoma area, growth of 5.2 and 6.8 inches respectively for I and II year-classes was recorded (Hall, 1951).

CHAPTER V

GAME AND FORAGE FISHES

Largemouth Bass

The largemouth bass was difficult to obtain in Heyburn Reservoir except by the use of rotenone. Occasionally the species appeared in the catch from trapping, about two specimens per week were taken during 1952. There were also a few nice catches by anglers, though, in comparison with most other new lakes, bass fishing was not good. The majority of the catches by anglers were made in the spring of 1952 and again in the fall of 1952 when the lake was less turbid. The 1950 year-class was the one appearing most commonly in the creel. Growth data are presented in Table IV and a geographical representation is shown in Figure 2.

TABLE IV

Calculated average total lengths, weights and annual increments for largemouth bass from Heyburn Reservoir

Year-Class	Age-Group	No. Fish	Av. Length Inches	Av. Weight Lbs.	Length Range	Calculated total length at end of year of life 1	2	3	4
1953	0	2	1.75	0.0034					
1952	I	0							
1951	II	19	9.12	0.41	(7.3-11.8)	5.47	8.16		
1950	III	67	14.54	1.95	(11-16.8)	5.24	10.36	13.26	
1949	IV	5	17.30	3.20	(17.1-17.6)	4.60	7.20	14.2	16.6
Total		93							
Average						5.10	8.38	13.46	16.6
Increment						5.10	3.28	4.08	3.14
Number of fish						91	91	72	5

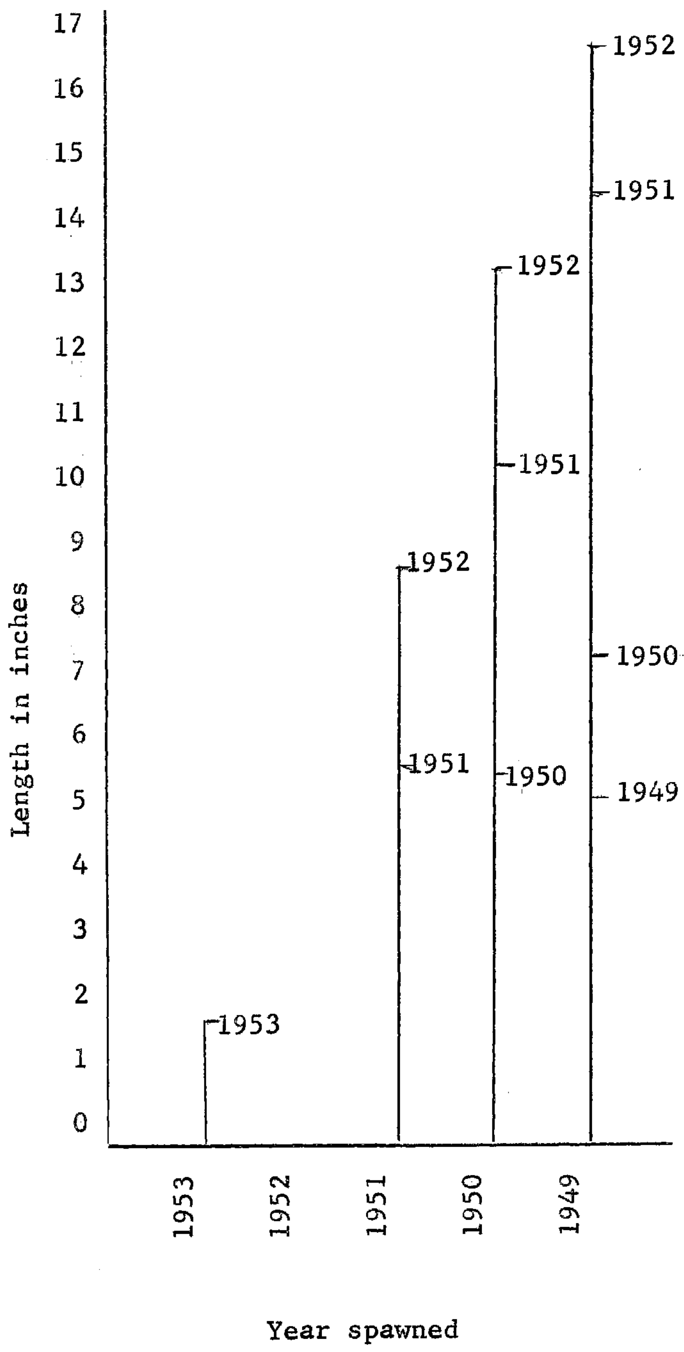

Figure 2 - Post impoundment growth history of Heyburn Reservoir largemouth bass showing growth by year-classes. The fish were taken during the summers of 1952 and 1953.

Age and growth were based on scale samples from 93 fish taken in traps in August and September of 1952 and with the use of rotenone in June and July of 1953.

The growth rate during 1951 was average in comparison with lakes farther north, though somewhat below that of Oklahoma lakes. Two-year-old bass, except those of the 1950 year-class, did not reach legal size. The success of the 1950 year-class in attaining a size of ten inches in two growing seasons can be correlated with the first two years of inundation. Water first reached conservation pool level in June of 1950 and fingerling bass (four and one-half to five inches long) were stocked the following fall. The growing season of 1951 was the period in which bass in Heyburn Reservoir made good gains.

TABLE V

Comparison of largemouth bass growth in Heyburn Reservoir with that in other lakes

Reservoir Authority	Average total length in inches at end of year of life 1	2	3	4	5
*Heyburn Reservoir, Oklahoma	5.1	8.4	13.5	16.6	
*Wister Reservoir, Oklahoma Latta (1952)	7.3	11.8			
Norris Reservoir, Tennessee Stroud (1948)	6.9	12.2	14.7	16.1	17.5
Foots Pond, Indiana Ricker and Lagler (1942)	4.0	7.2	9.4	14.6	
Grand Lake, Oklahoma Jenkins (1953)	7.2	12.6	15.4	17.2	18.8
Wisconsin Waters Carlander (1953)	3.3	7.4	10.5	12.5	14.0
Nebraska Waters Carlander (1953)	3.6	7.6	10.9	13.5	15.8

*New lakes (no more than three years of age)

Age and Growth

The members of the 1949 year-class were few and apparently were spawned by fish which were within the watershed at impoundment. Regardless of the origin of the 1949 year-class, it was a relatively small group as only about three percent of the catch obtained by the use of rotenone was of this year-class. The bass averaged 7.2 inches in length at the end of their second growing season which was considerably short of the length that bass commonly attain in two growing seasons under good conditions. In 1951, food conditions became excellent for the 1949 year-class bass. A good growth of seven inches was made during the 1951 season (third summer growth) which was about equal to the growth during their first two years. The fourth summer growth was also good; the increment of 2.8 inches was better than the best fourth-year increment shown for Grand Lake bass (Jenkins, 1953) in which the 1945 year-class fourth-year increment was 2.0 inches.

Seventy percent of the bass taken belonged to the 1950 year-class which was probably the first one spawned in the lake. It is possible that a considerable number were stocked fish of the 1950 year-class. If so, the modest growth of the age-group during the 1950 growing season may well be affected by the four and one-half- and five-inch fish which were stocked in the fall of 1950. The stocked fingerling bass, approximately 30 per surface acre, should have experienced a high rate of survival because they had already made fair growth, and competition must have been at a minimum. Even though the 1950 year-class averaged legal length by the end of their second growing season, 1951, there probably were not many "keepers" until late in the fall. Two-year-old bass from Wister Reservoir and Grand Lake averaged near twelve inches while those from Heyburn Reservoir were about ten and one-third inches long.

The 1951 year-class composed about twenty percent of the total catch of bass from Heyburn Reservoir. At capture, their sizes ranged from seven to eleven inches. This class showed the best first-year growth for the lake, 5.5 inches, which was relatively poor.

It is difficult to make statements with much confidence concerning the 1951 year-class bass since only twenty were taken. The scales of the smaller specimens, seven to nine inches long, taken by means of rotenone in June of 1953, lacked the second annulus. Those of this age-group taken in July, 1953 had completed the second annulus.

Largemouth bass representing the 1952 year-class were not taken during the periods of sampling.

No young-of-year bass were found in 1953 by poisoning the larger coves of the lake. Two specimens only were taken from the entire lake and those (each 1.75 inches long and 1.5 grams in weight) were collected July 25 while rotenoning Skeeter Creek, a small tributary of Polecat Creek about four miles above the dam. The area producing the two young bass was a cut-off pool about one hundred yards from Polecat Creek. By July 25, a large part of the growing season was past. The young bass should have been two or three times as long since Jenkins (1953) found young-of-year bass from Fort Gibson Reservoir to average four inches in length by July, 1953.

White Crappie

The white crappie was probably the most abundant game species in Heyburn Reservoir. Results from the use of rotenone in June and July of 1953 showed the species to rank fifth in the total number of fish taken. The larger crappie may have moved to deeper water before the rotenone operations were begun for specimens as large as those taken in traps in 1952 were not recovered. Trapping data from August and

September, 1952, revealed crappie to rank first in number and composed 43 percent of the total catch. The 1950 year-class was dominant numerically in all trapped collections and composed 88 percent of the crappie catch. The average length at capture was about six and one-half inches for age-group III. Growth data are shown in Table VI and Figure 3.

TABLE VI

Average calculated total lengths, weights and annual increments for white crappie from Heyburn Reservoir

Year-Class	Age-Group	No. Fish	Av. Length Inches	Av. Weight Lbs.	Length Range Inches	Average total length in inches at end of year 1	2	3
1953	0	1	1.37	.00069				
1952	I	10	3.8	0.037	(3.5-3.9)	2.72		
1951	II	88	5.31	0.095	(4.0-8.0)	3.1	5.4	
1950	III	132	6.5	0.15	(5.3-9.0)	3.25	5.8	6.8
1949	IV	4	12.3	1.20	(11.8-12.6)	1.80	10.4	12.0
Total		235						
Average						2.71	7.2	9.4
Annual Increment						2.71	4.49	2.2
Number of fish						234	225	136

Apparently, enough adult fish came from the creeks to accomplish a considerable spawn because the planted fish (4000 in November, 1950) were too few to appreciably affect the strength of the 1950 year-class. Conditions for the survival of fry apparently were good during the spring of 1950. Conservation pool level was first reached in June of that year and the terrestrial vegetation inundated probably provided shelter and, indirectly, food for the young crappie. It seems likely that most of the vegetation was not present for the following year-class.

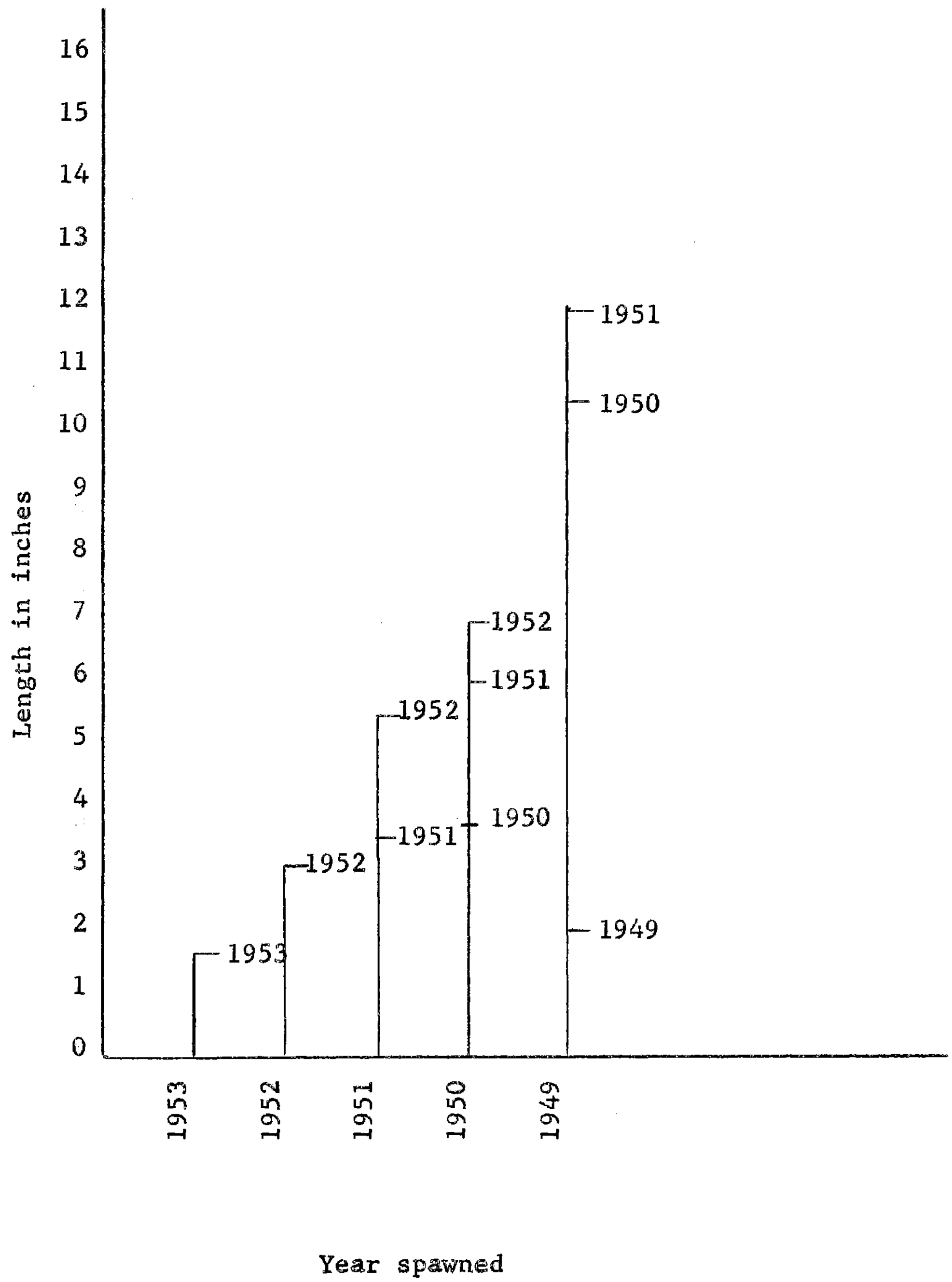

Figure 3 - Post impoundment growth record of Heyburn Reservoir white crappie captured during the summers of 1952 and 1953.

The rotenoning process made available considerable numbers of crappie of the four- to eight-inch lengths. Because of their large numbers, 20 specimens of each inch range were taken for measurement and scale samples to insure a usable number of each length-group. Data were collected from all crappie taken in traps during 1952.

Age and Growth

The 1949 year-class crappie presented a pattern of growth unlike that of any other year-class. The first year of life was one of poor growth, 1.8 inches, while the second year was exceptionally good; they grew to a length of 10.4 inches and were 12 inches long at the end of the third year of life. The figures are taken from a sample of only four specimens and may not represent the year-class accurately. During the summer of 1953, specimens of the 1949 year-class were not found. The largest crappie taken in 1953 was nine inches in length and a member of the 1950 year-class. The exceptional growth that the 1949 year-class made during 1950 must relate to conditions caused by the initial inundation of the lake basin.

TABLE VII

Comparison of growth of white crappie in Heyburn Reservoir with that of other lakes

Reservoir Authority	Average total length in inches at end of year of life 1	2	3	4
Heyburn Reservoir	2.8	5.9	6.8	12
Lake Texoma Wilson (1950)	3.8	5.6	7.3	8.9
Canton Reservoir Buck and Cross (1951)	4.1	7.8	10.4	
Wister Reservoir Latta (1952)	4.1	7.9	10.6	13.0
Tenkiller Reservoir Jenkins (1953)	5.0	11.0	12.4	
Cherokee Reservoir, Tennessee Stroud (1949)	1.5	8.7	11.6	
Foots Pond, Indiana Ricker and Lagler (1942)	2.8	5.8	8.6	10.2
Fort Gibson Reservoir Jenkins (1953)	5.0	8.9	11.1	
Harlan County Reservoir, Nebraska Orr (1955) unpublished	2.3	3.8		

The dominant 1950 year-class was present in numbers slightly greater than was the 1951 year-class. Growth of the young-of-year of 1950 (3.2 inches) was low for new impoundments but was near the average for the first year growth in older lakes of Oklahoma such as Grand Lake and Texoma. Plankton organisms, on which the young fish feed, seemingly were never present in great enough quantities to produce the growth characteristic of new lakes. The lack of basic productivity was reflected in the growth of all Age I groups. A striking comparison of the growth crappie made in the presence of abundant or limited food supplies can be seen in the 1950 growth history of year-classes III and IV. The spawn of other sunfishes in 1950 and 1951 undoubtedly contributed to the competition for food. The increment of the 1952 growing period for the 1950 year-class is the smallest recorded for the crappie of Heyburn Reservoir.

The 1951 year-class growth pattern followed closely that of the 1950 year-class, though during the first year of life, the average was 0.1 inch less. The 1952 increment was 1.9 inches of length compared with 1.1 inches for the 1950 year-class during the same period. It is possible that the somewhat fewer numbers of the 1951 year-class resulted in less competition for food. Reasons for the seemingly smaller spawn of 1951 are not clearly understood. A good spawn could have been expected as the environment should have been near a peak in 1951, judging from the basis of the growth record of the various year-classes. Growth during the 1952 season followed the downward trend exhibited by the other age-groups.

A single young-of-year white crappie was taken with rotenone July 27, 1953, from Cove III which had been treated with rotenone previously on June 11. The specimen was 1.3 inches in length and .00069 pound in weight and possibly was spawned after the June rotenone operations. Young-of-year crappie as small as 1.6 inches were taken in Canton Reservoir on July 13, 1950 by Buck and Cross (1951). Spawning in Canton Reservoir was thought to have continued into late June.

Black Crappie

The black crappie was represented in the sample by two specimens though 4,000 were stocked in 1950. It would seem that the species was unsuccessful in becoming established in Heyburn Reservoir. The two specimens were taken in the rotenoning of Cove I, June 9, 1953, and both individuals were of the 1950 year-class. The rate of growth closely parallels that of the white crappie, being the same size at the end of the third year (6.8 inches in length). During the first year, the black crappie grew better, on an average, than the white crappie, 3.2 inches average for the two specimens and 2.8 for the white crappie. The origin of these two black crappie is a matter of speculation. It is probable that they were planted since they were of the same year-class as the ones planted. The length range of the two fish was rather wide (5.9 - 8.4 inches), with weights of 0.09 and 0.28 pounds respectively. If wide variability is characteristic of the black crappie population in Heyburn, more data must be gathered for substantiation; it could not be safely measured from the present information.

Bluegill

The bluegill was the third most abundant fish species in the lake according to the data collected by the use of rotenone. They composed 5.5 percent of the take with rotenone and 4.4 percent by trapping. It may be assumed on the basis of collection data that approximately five percent of the lake's population was bluegill. Growth data are presented in Table VIII. Few people fished for bluegill and the harvest was very small. A few nice catches were seen during August, 1952. The common methods of sport fishing generally used by anglers at Heyburn Reservoir were selective against the bluegill. Natural bait fishing for crappie, bass and channel catfish or plug and fly fishing for bass were the common angling methods; thus the hooks used were generally too large for bluegill.

TABLE VIII

Average calculated total lengths, weights and average annual increments for bluegill from Heyburn Reservoir

Year-Class	Age-Group	No. Fish	Av. Length Inches	Av. Weight Lbs.	Length Range	Calculated total length at end of year of life 1	2	3	4
1953	0								
1952	I	20	2.5	0.01	(2.2-2.8)	1.3			
1951	II	40	3.9	0.02	(2.8-3.2)	2.1	3.6		
1950	III	70	5.1	0.13	(3.5-5.5)	2.1	4.3	4.9	
1949	IV	18	5.7	0.16	(5.4-6.0)	2.2	3.9	4.6	5.3
Total		148							
Average						1.9	3.7	4.8	5.3
Increment						1.9	1.8	1.1	0.5
Number of fish						148	128	88	18

Age and Growth

The scales of 148 fish were used for determining the age and growth of the bluegill sample. The 1949 year-class was the oldest age-group collected and was represented by 18 individuals. Of these, the majority were taken by rotenone and some data were gathered in creel census. Trap and net selectivity against the largest bluegills seemed a reality. Table IX shows a comparison of the growth of bluegills from Heyburn Reservoir with the growth of bluegills from some other lakes. Lewis (1950), working on a lake in Iowa, noted that the largest bluegills were present in creel census returns, but were not taken by netting. During August of 1952, a few of the larger bluegill were taken by anglers, fishing in mid-lake off steep rocky banks, in Heyburn Reservoir. The first year growth rate of age—groups II, III, and IV were almost identical, there being only 0.1 inch of length difference among the three groups. This would indicate that the environmental conditions for bluegill fry were comparable during 1949, 1950, and 1951. The first-year growth of the 1952 year-class dropped to 1.3 inches which is probably a coincident of the high spring and early summer turbidity of 1952. An average of 1.9 inches for all first-year growth was poor for new lakes in Oklahoma. Bluegill from Wister and Canton Reservoirs made first-year growths of 3.2 and 3.4 inches respectively.

The 1952 year-class grew a scant 1.3 inches the first year which was below the average of 1.6 inches for an old lake in Indiana, Ricker and Lagler (1942). The second- and third-year growth for the various year-classes did not show any periods of accelerated growth as shown by some of the other species. The 1949 year-class crappie made exceptional growth during the second growing season. The two examples reflect good conditions in both 1950 and 1951, while the 1952 season was unfavorable for all year-classes. The relatively low population of bluegills in Heyburn Reservoir suggests a minor role for the species. Some factors that perhaps influenced the growth of bluegills were unfavorable habitat, few aquatic plants, and scarcity of insect larvae and bottom-type foods.

TABLE IX

A comparison of the growth of bluegill from
Heyburn Reservoir with growth from other lakes

Locality	Average total length in inches at capture for age-groups				
Authority	1	2	3	4	5
Heyburn Reservoir, Oklahoma	1.9	3.7	4.8	5.3	
Wister Reservoir, Oklahoma Latta (1952)	3.9	5.4	6.7	7.1	7.9
Redwine Lake, Oklahoma Hall (1950)	3.0	4.4	5.4	6.3	7.1
East Lake, Iowa Lewis (1950)	1.7	3.6	5.6	7.0	7.5

Green Sunfish

The green sunfish was a major component of the fish population of Heyburn Lake, ranking second in the collection by rotenone and fourth in trapping returns. The species appeared frequently in the creel census and the fishermen commonly referred to it erroneously as "goggle eye." The green sunfish has apparently been more successful than the bluegill in Heyburn Lake. Fishermen frequently lamented the inability of the species to reach a desirable size as the individuals that attained six inches or more were desirable sport fish when taken on light tackle.

Age and Growth

Age and growth of the green sunfish were based on determinations taken from the scales of 142 fish, including seven year-classes (Table X). The 1947 and 1948 year-classes were each represented by one fish. No valid conclusions could be drawn from such inadequate samples. The 1949 year-class was represented by a small sample of 20 fish and inferences made about the population would be doubtful. The dubiousness of such small samples may be seen in comparing the 1949 year-classes of the bluegill and green sunfish. Computations of the two samples show the green sunfish to average considerably larger than the bluegill, about 20 percent in length and 40 percent by weight. The other year-classes compare closely with the bluegill and the first-year average for green sunfish was 1.8 inches of length as to 1.9 for the bluegill.

As with other species, the rate of growth in Heyburn Lake was slow in comparison with the growth of green sunfish in other new lakes. Growth for the species in Canton, Buck and Cross (1951), averaged 2.4 inches the first year. The green sunfish in Heyburn Lake reached a length of six inches in their fourth year, which is about average. Occasionally the species attains a length of six inches in the third year and in the northern states studies show that the six-inch length was not reached until after the sixth year of growth.

TABLE X

Average calculated total lengths, weights and average annual increments for the green sunfish from Heyburn Reservoir

Year-Class	Age-Group	No. Fish	Av. Length Inches	Av. Weight Lbs.	Length Range Inches	Calculated total length at end of year of life 1	2	3	4	5	6
1953	0										
1952	I	20	2.6	0.01	(2.2-2.8)	1.8					
1951	II	60	3.9	0.07	(3.0-5.1)	1.8	3.5				
1950	III	40	5.4	0.13	(4.5-5.9)	2.2	3.8	4.9			
1949	IV	20	6.7	0.26	(6.0-8.3)	1.9	3.2	5.2	6.4		
1948	V	1	6.9	0.28		1.8	3.0	5.4	6.0	6.3	
1947	VI	1	8.8	0.44		1.4	3.2	4.8	5.9	6.8	7.6
Total		142									
Average						1.8	3.3	5.0	6.1	6.5	7.6
Increments						1.8	1.5	1.7	1.1	0.4	1.1
Number of fish						142	122	62	22	2	1

Redear Sunfish

A total of 36,000 redear sunfish fingerling were stocked in Heyburn Reservoir in November, 1950 and March, 1951. The sample collected was composed of 16 individuals taken in wire traps, gill nets and with rotenone. All specimens were of the 1950 year-class and averaged 5.9 inches in length and 0.15 pound in weight at capture. The growth rate of the species in Heyburn Reservoir was slightly higher than that of the green sunfish, which will not normally compare in size with the redear sunfish when good conditions for growth are present. The inability of the redear to become established in the fish population of the lake indicated unfavorable conditions. A sufficiency of food and suitable spawning conditions within the environment are basic requirements for any successful fish population. Though definite proof was lacking that the redear sunfish was unable to reproduce, a serious food problem was a reality. Snails, a staple food for the species, were almost totally absent.

Miscellaneous Sunfishes

The longear and orangespotted sunfishes are considered together here as miscellaneous sunfishes. When thus considered, they composed a group which ranked third in the overall numbers collected. The orangespotted was the most numerous of the two species by a ratio of about five to one. Prominance of these species doubtlessly produced considerable competition for food with the smaller fishes of the game species. Their importance as forage fish was probably reduced by the presence of gizzard shad, a species which is not considered a competitor for the same foods. Since sport fishing for pan fish in Heyburn has been insignificant and will likely not improve in the future, the consideration of these fishes as competitors may be viewed as academic.

Channel Catfish

One of the most prominant game fish species in Heyburn Lake was the channel catfish. According to sampling data, it ranked third in trap and eighth in rotenone collections. Channel catfish were taken rather frequently by anglers in comparison with the catches of other game species. The best catches were made by trotline fishermen in the channel of the upper Polecat Creek Arm; however, no "bag limit" catches were seen by the writer. Spawning sites were numerous in brush piles, built in several areas, and in rocky creek banks. Survival of the young seemed high.

Age and Growth

The channel catfish age and growth data were taken from a sample of 246 fish (Table XI and Figure 4). Thin cross-sections were made of the pectoral spines and age determinations were made by counting growth rings (annuli) in a manner similar to that described by Sneed (1951). Growth of the channel catfish was poor in comparison with that in new lakes of Oklahoma and only slightly above that for stunted populations reported from some of the larger lakes, Hall and Jenkins (1952) (Table XII). Legal length of Heyburn channel catfish was not reached until the third or fourth summer. Under good conditions it may be reached in two summers. Jenkins and Leonard (1953) found channel catfish in Tenkiller Reservoir to average 11.6 inches in length after two years of life.

TABLE XI

Average calculated total lengths, weights, and annual increments for channel catfish from Heyburn Reservoir

Year-Class	Age-Group	No. Fish	Av. Length Inches	Av. Wt. Lbs.	Length Range Inches	Calculated total length at end of year of life 1	2	3	4	5	6	7
1953	0	40	2.2	0.004	(1.5-2.8)							
1952	I	20	5.9	0.07	(5.5-6.1)	2.9						
1951	II	48	7.9	0.15	(7.2-8.8)	3.4	6.9					
1950	III	115	9.8	0.30	(8.4-12.8)	2.6	6.9	9.2				
1949	IV	20	14.4	1.15	(11.6-22.0)	3.2	6.7	10.2	13.8			
1948	V	1	18.0	2.80		3.3	5.3	8.1	11.7	16.8		
1947	VI	1	20.8	3.15		5.1	7.8	8.9	12.2	15.5	19.1	
1946	VII	1	23.2	3.75		3.4	5.3	7.7	10.3	14.4	18.2	22.1
Total		246										
Average						3.4	6.5	8.8	12.0	15.5	18.6	22.1
Annual Increment						3.4	3.1	2.3	3.2	3.5	3.1	3.5
Number of Fish						206	186	138	23	3	2	1

Seven year-classes were found in the sample, the last three being represented by one fish each; therefore, discussion of age-groups V, VI, and VII are speculative.

The 1949 year-class was represented by a sample of 12 individual fish of rather wide length-range. Because of the range and small sample size, the data available probably did not provide an unbiased estimate of the population. Of the seven year-classes represented, the 1949 year-class was the only one to reach or surpass the legal limit (10 inches) in the third year of life.

The 1950 year-class composed about 50 percent of the total channel catfish sample and, therefore, must be considered the dominant year-class. However, during the summer of 1954, Buck (personal communication) found the 1951 year-class to be more numerous than the 1950 year-class by a ratio of about three to two. Since the 1950 and the 1951 year-classes were the dominant ones in both collections it may be assumed that the 1950 year-class which appeared dominant in 1953, was reduced by 1954, by natural causes to fewer numbers than the 1951 year-class. The relatively large size of the 1950 and 1951 year-classes probably resulted in considerable competition for food, perhaps causing them to be less successful than the 1949 year-class. The 1951 year-class made the best first-year growth of any age-group, a condition consistent with other species. The 1951 growing season seemed the best for most age-groups of all species. The size of the 1950 and 1951 year-classes supports the thinking of many that a sufficient brood stock is usually present in the stream to stock the impoundment.

The 1952 and 1953 age-groups were represented by smaller samples than the preceding two, and at a time when they should have been the most numerous. It, therefore, seems that the deterioration of environmental

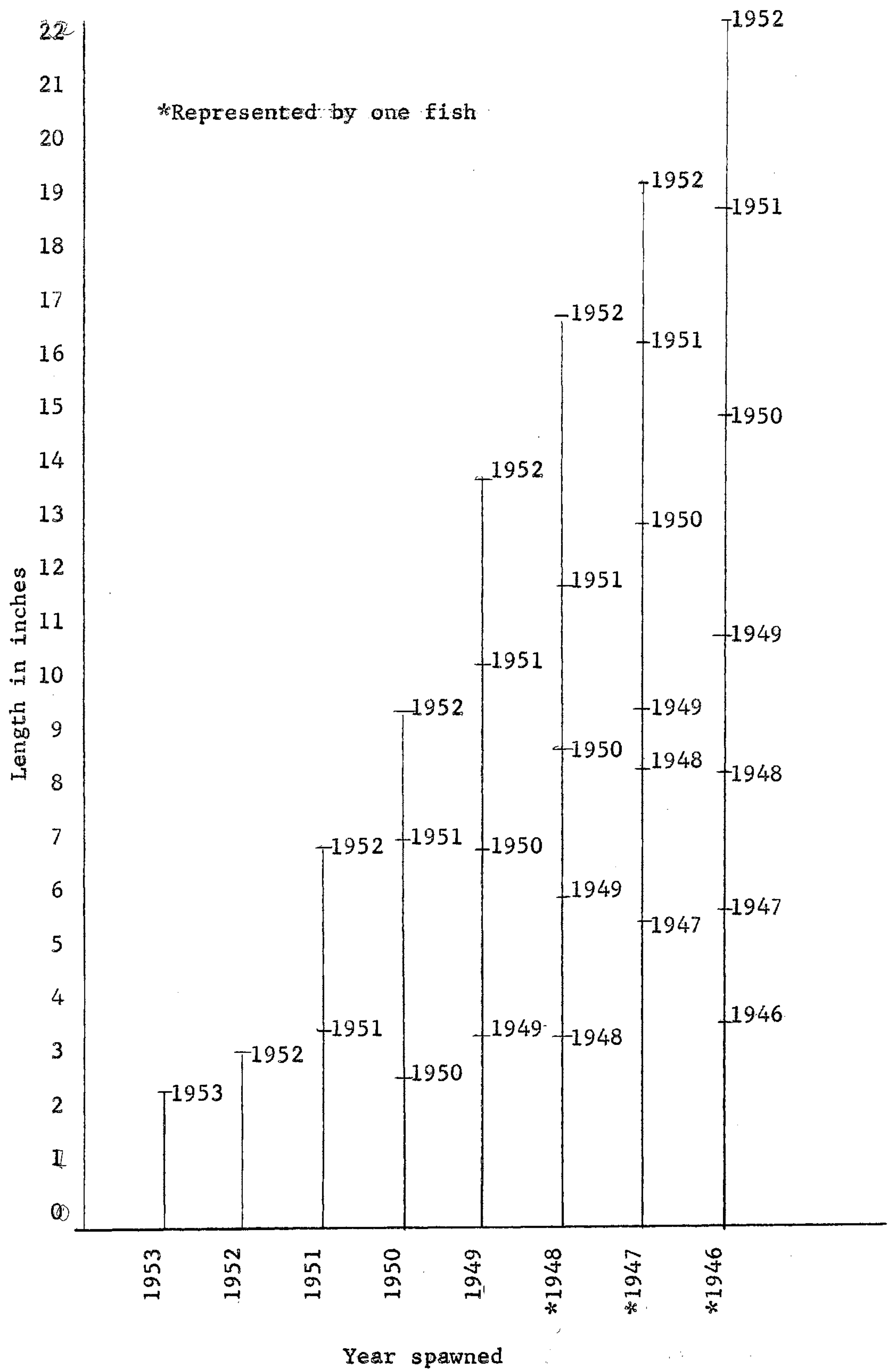

Figure 4 - Growth chart of channel catfish taken from Heyburn Reservoir during the summers of 1952 and 1953.

conditions had a depressing effect on the spawning success of the channel catfish. The 1952 year-class seemed quite uniform. The length ranged from 5.5 to 6.1 inches, correlating closely with stunted populations reported by Hall and Jenkins (1952). The fish were generally in poor condition. The young-of-year were absent from the June, 1953, rotenone collections, but were found in considerable numbers in Cove III when rotenoned a second time in late July. Young-of-year averaged 2.25 inches in length and about 0.004 pound in weight. It appears that spawning in 1953 was accomplished in the deeper, more open areas of the lake and the young migrated into the coves. Considering the growth history of preceding year-classes and the conditions in the lake it would seem unlikely that the young-of-year could have been spawned after June 11, 1953.

TABLE XII

A comparison of growth of the channel catfish from Heyburn Reservoir, 1952 and 1953, with growth of channel catfish from other lakes

Locality Authority	Average total length in inches at end of year of life 1	2	3	4	5	6
Heyburn Reservoir, Oklahoma	3.4	6.5	8.8	12.4	15.5	18.6
Wister Reservoir, Oklahoma Latta (1952)	11.1	13.6	16.0	19.4	22.8	23.8
Grand Lake, Oklahoma Jenkins (1953)	2.7	5.5	7.9	10.3	12.8	15.7
Salt Plains Reservoir, Oklahoma Jenkins (1951)	6.1	8.7	12.0	16.4	19.1	21.3
Canton Reservoir, Oklahoma Buck and Cross (1951)	6.6	10.6	14.4	21.4		
Iowa, Mississippi River Carlander (1953)	3.0	6.3	9.1	11.7	14.2	16.6

<u>Flathead Catfish</u>

The flathead catfish population in Heyburn Reservoir seemed small. Twenty-eight specimens were captured, 15 with rotenone and 13 with nylon tangle nets. Tangle nets were used during the week of July 19 to 25, 1953; flatheads and turtles were the principal animals taken. The only exception was a 1.75-pound channel catfish. The netted flatheads ranged from 5.5 to 13 pounds in weight and from 19 to 29 inches in length. Growth data are shown in Table XIII.

TABLE XIII

Summary of the calculated lengths and annual increments in inches for flathead catfish collected from Heyburn Reservoir, in 1953

Year-Class	Age-Group	No. Fish	Av. Length Inches	Av. Weight Lbs.	Length Range Inches	Average total length at end of year 1	2	3	4
1953	0	3	2.6	0.01	(2-2.8)				
1952	I	7	5.3	0.13	(4.9-9.7)	5.5			
1951	II	6	17.3	1.30	(12-22)	7.0	15.4		
1950	III	12	25.1	7.44	(22.5-29)	6.4	11.4	22.2	
Total		28							
Average						6.3	13.4	22.2	
Increment						6.3	7.1	8.8	
Number of fish						25	18	12	

The average growth of the flathead catfish was above that for the state (Table XIV). The success of the flatheads in Heyburn is not understood. Analysis of the growth history shows that conditions during the second year of life were favorable for the species. The species alone shows growth which is greater than that in other lakes. The presence of a relatively large population of slow-growing gizzard shad provided a possible food supply though no data were collected from stomach contents. The specimens taken in nets invariably had empty stomachs, and those fish taken with rotenone had usually eaten a variety of small fishes which were more quickly distressed by the rotenone.

TABLE XIV

Comparison of growth of flathead catfish in Heyburn Reservoir with that in other Oklahoma waters

Locality Authority	Total length in inches at end of year 1	2	3	4	5
Heyburn Reservoir	6.3	13.4	22.2		
Grand Lake (Neosho Arm), Oklahoma Leonard (1952)	5.5	10.2	15.0		
Lake Wagoner, Oklahoma Leonard (1952)	3.5	9.0	15.5		
Oklahoma (Average of 20 lakes) McCoy (1953)	4.6	9.7	15.2	20.0	23.4

The fish in all year-classes made good growth each year. However, the 1951 year-class surpassed the growth of the 1950 year-class during the corresponding first two years of their existence. All year-classes found grew faster during their first year than did the first year-class in Neosho River Arm of Grand Lake, an area which produced the best growth in Grand Lake, Jenkins (1953).

The size of the sample of flathead catfish was too small to give reliable information concerning the size of the population of the species in the lake. Occasional catches have been made by trotline fishermen. If the data recorded are representative of the status of flatheads in Heyburn, some good catches may be expected in the future.

Bullheads

The black and the yellow bullhead catfish seemed to be numerous in the lake. Nearly three times as many flack as yellow bullheads were collected. In the collection from traps, bullheads ranked second to white crappie and composed 22 percent of the total catch of fish. During August and September of 1952, some of the traps were baited with corn or cottonseed meal. About two quarts of the meal was wrapped in a piece of burlap and tied in the trap. The catch from the baited traps was predominantly composed of bullheads and small channel catfish and seldom contained other species. The stomach contents revealed both the bullhead and the channel catfish to be proficient in extracting the bait from the burlap.

Large specimens of bullheads were not taken in traps. The largest measured 8.6 inches in length. During the Labor Day week end of September, 1952, two specimens (average weight 1.5 pounds) were taken by trotline fishermen. The spines were not obtained for age and growth determinations. As would be expected, all age-groups representing the years of impoundment were present. Young-of-year seemed abundant; compact schools were observed on many occasions.

Carp

Only four specimens of carp were taken during the entire study. Two three-pound females, of the 1950 year-class, were taken together in a trap baited with corn meal in September of 1952. Two specimens, of the 1951 spawn, taken with rotenone from Cove IV, weighed about 1.5 pounds each. Apparently the carp population in Heyburn Lake was small. With some adult fish in the lake, it was surprising to find no specimens of either the 1952 or 1953 year-classes.

Investigations of the fish population of Grand Lake, Jenkins (1953) showed a marked decline in the carp population, resulting from conditions affecting their breeding. Fishermen commonly referred to the more abundant carpsucker as carp, and many persons were of the opinion that the lake was "overrun" with them. However, strengthening of the carp population may occur.

Following a rain in late June of 1953, great numbers of carp were observed in the stilling basin. On the afternoon of July 3, according to eye witness reports, the fish showed signs of distress and soon the water of the basin was covered with dying fish. Several hundred pounds were estimated to have been removed. It may be assumed that the carp taken from the stilling basin had migrated up Polecat Creek from the Arkansas River rather than having come from the lake, because the lower part of the creek was a flowing stream during the early summer.

Carpsucker

The northern carpsucker was present in the collection in considerable numbers. Age and growth determinations were made from a sample of 165 fish. The species was taken more commonly from coves with muddy bottoms and in the shallow mud bottom areas. The scales of the carpsucker were difficult to read, but the two year-classes represented (1950 and 1951), were present in about equal numbers. The 1950 spawn was slightly more numerous. A single two-inch young-of-year specimen was taken July 27, 1953, when Cove IV was treated with rotenone, while no specimens belonging to the 1952 year-class were found. Both the 1950 and 1951 year-classes were remarkably uniform in length range. The 1950 group ranged from 11.5 to 12.4 inches and the 1951 year-class from 10 to 10.8 inches in length. The 1951 growing season was the best one for the carpsucker as well as for most other species. The average annual increment for the two classes in 1951 was 4.3 inches, whereas, that for 1950 was 3.7 inches. The uniform growth pattern in Heyburn Reservoir showed sharp contrast to that found in Canton Reservoir where great variability was found by Buck and Cross (1951).

Reproduction of carpsuckers during the spring and summer of 1952 and 1953 seemed to have been drastically reduced. The situation coincides with periods of high turbidity.

Gizzard Shad

Gizzard shad were seldom taken in nets and traps, as only slightly over one percent of the shad captured were taken with such gear. In the rotenone collection, however, 36 percent of the total catch was of this species. The shad was the most abundant species in the lake, though only three year-classes (1950, 1951, and 1952) were represented in the collections. Young-of-year were not found in 1953. The 1951 year-class was dominant in number, which was in direct contrast with many of the other species in the lake. Growth data are shown in Table XVI. When compared with other lakes, growth rates were extremely low.

TABLE XV

Summary of calculated lengths and annual increments in inches for the gizzard shad collected from Heyburn Reservoir in 1953

Year-Class	Age-Group	No. Fish	Av. Length Inches	Av. Weight Lbs.	Length Range Inches	Average total length at end of year 1	2	3
1953	0	0						
1952	I	40	4.9	0.06	(4.1-6.12)	3.9		
1951	II	60	7.6	0.10	(6.9-8.8)	4.2	6.3	
1950	III	30	8.5	0.13	(7.8-9.2)	4.1	6.1	7.3
Total		130						
Average						4.1	6.2	7.3
Increment						4.1	2.1	1.1
Number of Fish						130	90	30

The gizzard shad made rapid gains in lakes that had an abundant phytoplankton crop. Ewers and Boesel (1935) demonstrated that planktonic algae are by far the most important food for the gizzard shad. The retarded growth of the species in Heyburn Reservoir suggests a severe shortage of phytoplankton. The fact that shad have grown slowly may have increased their value as forage fish for the game species by providing a smaller-sized food item.

TABLE XVI

A comparison of the growth of the gizzard shad from Heyburn Reservoir with that from other lakes

Locality Authority	Average total length in inches at capture for age-groups 1	 2	 3	 4
Heyburn Reservoir, Oklahoma	4.9	7.6	8.5	
Wister Reservoir, Oklahoma Latta (1952)	6.3	10.2		
Poteau River, Oklahoma Hall (1950)	7.9	9.1	12.4	
Foots and Grassy Ponds, Indiana Lagler and Applegate (1952)	7.6	9.7	10.5	
Beaver Dam Lake, Illinois Carlander (1953)	5.6	10.1	12.2	14.2

Apparent Populations

The catfishes, some small sunfishes and minnows appeared to be maintaining their numbers. In most cases, the 1950 year-class was most numerous and was derived from the first spawn in the lake.

Several species were represented in the collections by only a few individuals. The redear sunfish, though planted in considerable numbers (36,000), seemed to have grown and reproduced poorly. The black crappie and warmouth sunfish were represented in the collections by only two individuals of each species. Orangespotted sunfish and longear sunfish, bluegill and largemouth bass were relatively numerous in the early populations. The green sunfish, white crappie, channel catfish and bullheads seemed to be the species most numerous for harvest.

The largemouth bass were apparently in good condition and possessed considerable quantities of visceral fat at the time of capture. Although the turbidity was about 300 parts per million, the bass appeared to be able to feed successfully in the absence of visual aid. According to Curtis (1949) the eye of the fish has been shown to be less efficient than the eye of man and at 300 parts per million turbidity, the human eye can see objects at a distance of less than three inches.

The roughfish populations had developed slowly. Carp and shortnose gar were represented in the collections by four and five specimens respectively. The carpsucker, although present in modest numbers, apparently had not spawned successfully the past two seasons since no age-group-I fish were found and only one young-of-year recorded. Returns of flathead catfish seemed to show a small population of rapidly-growing fish. The species, in Heyburn Reservoir, was the only one making good growth.

Forage fish were present. The plains red shiner was the most abundant of the minnows, though probably occupying a minor role as a forage fish. The gizzard shad, the most numerous forage fish and doubtlessly the most abundant species in the lake, probably occupied a major role as food for the game species. Good spawns were made by the shad in 1950 and 1951, but the actual number probably was small when compared to the shad population of 1949 and 1950 in Canton Reservoir. Buck and

Cross (1951) reported travelling by boat two miles through a continuous school of shad. Latta (1952) reported an estimated 23,000 fish, overwhelmingly shad, killed following the rotenoning of a cove of 2.25 acre-feet of water in Wister Reservoir. An estimated 8,000 fish were killed as a result of rotenone application in four coves containing 51 acre-feet of water in Heyburn Reservoir.

Reasons for the mediocre success of the fish populations in Heyburn Reservoir during the first years of impoundment and the later failure of some species to grow and reproduce were inherent in the environmental factors on the watershed and in the lake. Decline of conditions favorable for growth is likely to occur in all reservoirs, but in Heyburn the recession came rapidly.

CHAPTER VI

LIMNOLOGICAL CONDITIONS

Data of limnological conditions were collected during August and early September of 1952 and the summer of 1953. Also during the summer of 1953 a limnology class conducted by Dr. I. E. Wallen collected data which were contributed to the study. Tabular representation of data is given in Table XVII and a comparison of some limnological conditions of Heyburn with those of some other lakes is shown in Tables XVIII and XIX.

TABLE XVII

Physical and chemical data collected in Heyburn Reservoir during the summers of 1952 and 1953

Date	Depth in feet	Temperature Air	Water	ppm Turbidity	ppm O_2	ppm CO_2	Alkalinity M. O. ppm	pH
9/52	surface	87°F	80°F	60	5.0	0.0	6.0	7.8
	10		79	64	5.0	1.5	6.0	7.8
	20		78	66	3.6	4.0	6.2	7.6
7/53	surface	90	82	280	4.6	0.0	3.5	7.4
	10		79	300	4.4	2.5	3.5	7.4
	20		77	360	4.2	3.3	4.0	7.2
	32		59	525	0.0	8.0	4.0	7.0

Physical-Chemical

Determinations for dissolved oxygen, hydrogen-ion concentration, alkalinity, carbon dioxide and turbidity were made to facilitate identification and understanding of various conditions affecting productivity of Heyburn Reservoir.

1. Hydrogen-ion Concentration

The pH values at the surface ranged from 7.4 in July of 1953 to 7.8 in August of 1952 at which time turbidity was about 60 parts per million. A reading of 7.0 was taken near the bottom in the deepest part of the lake.

2. Dissolved Oxygen

Summer readings of dissolved oxygen ranged from 0 at the bottom, at maximum depth near the dam, to 4.6 parts per million at the surface. Except for a small area near the dam, protected from prevailing winds, the water was usually sufficiently stirred by wind action to preclude xoygen deficiency.

3. Carbon Dioxide

The carbon dioxide readings ranged from 0 at the surface to 7.8 parts per million at the bottom in the deepest part of the reservoir.

4. Temperature

Water temperature varied from brief periods of freezing in winter to 82 degrees F. recorded at the surface in July, 1953. Thermal stratification was found only in the deepest, most protected areas as the prevailing winds were usually of sufficient strength to keep the water circulated.

5. Alkalinity

Alkalinity of the water in Heyburn Reservoir was remarkably low. During the late summer of 1952, the highest surface reading was six parts per million methyl orange alkalinity. At that time turbidity, in the lake proper, was the lowest recorded during the study. Turbidity during the following summer (1953) was near 300 parts per million. The low alkalinity value of the water in Heyburn provided one of the most important indicators of the extremely low productivity. Since the carbonates are primarily compounds of carbon dioxide with calcium and magnesium, lack of such essential elements was obvious. Welch (1935) stated, "It seems also to have been well established that the more calcium and magnesium in water, other things being the same, the greater the productivity." Moyle (1946) believed alkalinity and total phosphorus to be the most important indices of productivity. In comparing alkaline quality of the water of Heyburn Reservoir with that in other reservoirs it was found to be exceedingly low and was probably one of the most limiting factors to biological productivity.

6. Turbidity

One of the most significant items of data collected, relating to the low productivity of Heyburn Reservoir, was the persistent high soil turbidity. During the study period, turbidity readings ranged from a high of approximately 300 parts per million at the surface to 500 at the bottom in the deepest part of the lake. After long periods without rainfall, the turbidity dropped considerably but increased after substantial rains.

According to Irwin and Stevenson (1951) the turbidity of water in Oklahoma generally is due to nonsettling colloidal suspensions of montmorillonite (hydrous aluminum silicate) type clay. The vegetation innundated by the impounded water decays and hydrogen ions are released. The presence of hydrogen ions brings about flocculation of clay particles by neutralizing the negative charges of the clay. The flocculated particles then gain sufficient weight to settle to the bottom. Apparently in Heyburn, the excess of hydrogen ions, produced by the decomposition of innundated vegetation, was obliterated by silt-laden runoff water in the spring of 1952. Up to that time the lake was clear and since then it has become turbid. The quality and character of the soil of the watershed, being extremely low in nutritive elements, probably contributed little to upholding the level of hydrogen ion concentration. According to Langlois (1941) turbidity was one of the processes operating in Lake Erie to reduce the fish populations. Roach (1936) believed turbidity generally has a limiting effect, both directly and indirectly, on aquatic biota and that phytoplankton organisms are affected directly by the amount of turbidity. The effects of turbidity on fishes have been reported by Van Oosten (1948), Swingle (1949), Wallen (1951) and others. Schneburger and Jewell (1928) and Moore (1937) have discussed effects of turbidity on fish culture and food production. Moen (1947) believed turbidity had a depressing effect on angling through the inability of fish to see the bait. The effect of turbidity on the spawning success of fishes has been discussed and it is gnerally considered to have a depressing effect. During the spring and summer of 1952 and 1953, few young-of-year fish were collected. Surface turbidity in excess of 250 parts per million was present throughout the spring and early summer of both years and was believed to be a limiting factor to successful spawning. Only two young-of-year largemouth bass and a single young crappie were taken in the rotenone samples of 1953. During the summers of 1954 and 1955, Buck (1955) collected a few young-of-year largemouth bass, following rotenone applications from the upper arms of the lake. Severe drought conditions had prevailed and the young bass were taken from water with a turbidity of less than 50 parts per million.

In comparing the potential productivity of reservoirs, the physical-chemical conditions are important indicators. The writer did not find in the literature a report of limnological conditions, in a reservoir, which were more unfavorable to biological productivity than those encountered in Heyburn. The undesirable conditions of alkalinity and turbidity in Heyburn Reservoir were undoubtedly related directly to the watershed. In studying plant nutrient losses in silt and water in the Tennessee River system, Fippin (1945) found such losses great and variable from one watershed to another. Mortimer (1941) believed that "a lake traps for organic production a part of the available 'chemical potential' of a drainage system which would otherwise be more rapidly lost to the sea." Thompson (1930) found a correlation between soil fertility and the size and condition of fishes. The physical-chemical conditions, abundance, and growth of fishes in Heyburn Reservoir, if compared to those of some other reservoirs, as shown in Table XIX, would indicate its watershed to be poorer than the others.

TABLE XVIII

Comparison of some physical-chemical conditions in Heyburn Reservoir with those of some other reservoirs

Reservoir Surface area Authority	Surface Turbidity Max. ppm	Alkalinity M. O. ppm	pH	Summer Maximum Temp. F.	Wind Action
Heyburn, Okla. 1070 a.	300	3.5	range (7.0-7.4)	92	moderate
Wister, Okla. 4000 a. Latta (1952)	39	range 14-39	(7.8-8.6)	89	moderate
Canton, Okla. 4000 a. Buck & Cross (1951)	clear	138	(7.8-8.6)	90	high
Bedford, Tenn. 65 a. Chance (1946)	clear	63	8.4 av.	82	moderate
Tullhoma, Tenn. 40 a. Chance (1946)	clear	25	7.3 av.	83	moderate
Harlan Co., Nebr.* 1300 a.	40	85	8.2 av.	79	high
McConaughy, Nebr.* 35,000 a.	clear	95	8.5 av.	76	high
Whitney, Nebr.* 1200 a.	secchi 4"-9"	160	8.6 av.	82	high

*Investigations by O. Orr

Phytoplankton

During the summers of 1952 and 1953, plankton was extremely scarce in Heyburn Reservoir. Surface turbidity during the period averaged over 200 parts per million. Claffey (1955), studying the effects of turbidity on plankton and bacterial populations of numerous lakes and farm ponds in Oklahoma, reported that unfavorable plankton-turbidity relationships in Heyburn Reservoir occurred in late 1953 and 1954.

The plankton count from a surface sample taken in July, 1953, when the turbidity range from the surface to bottom was 280 to 525 parts per million, revealed fewer than 100 plankters per liter. During the fall, surface turbidity dropped to 160 parts per million and plankton numbers increased to 500 per liter. The dominant forms were unicells and filaments of green and bluegreen algae, diatoms and fragments of water-mold hypha.

Claffey (1955) believed that reduction of light penetration by soil turbidity was a limiting factor to plankton production in impoundments. Meyers and Heritage (1941) working on Lake Erie found photosynthesis in *Ceratophyllum demersum* ceased at eight to ten meters in minimum turbidity, while at maximum turbidity the critical point was between one and two meters. Ellis (1936) found that the depth at which 99.9 percent of the light was screened out ranged from 84 mm. (3.3 inches) in the Missouri River to many feet in a deep mountain stream in Mexico. The statements of a number of investigators accede to the premise that soil turbidity reduces phytoplankton populations (Prescott, 1939; Chandler and Weeks, 1945; Silvey and Harris, 1947; Aldrich, 1949; Leonard, 1950).

TABLE XIX

Some limnological and related conditions, other than physico-chemical, of Heyburn Reservoir as compared with the lakes listed in Table XVIII

Reservoir	Bottom Fauna	Plankton	Aquatic Plants	Depth	Watershed size Fertility	Productivity
Heyburn	scarce	scarce	scarce	10'av.	large poor	extremely low
Wister	fair	fair	- -	8'av.	large fair	fair
Canton	scarce	abundant	- -	35'	large high	high
Bedford	- -	- -	- -	125'max.	medium good	good
Tullahoma	- -	- -	- -	30'max.	medium low	low
Harlan Co.	good	abundant	few	55'max.	large high	high
McConaughy	scarce	good	scarce	142'max.	large high	high
Whitney	few	poor	scarce	12'max.	small good	good

Zooplankton

Zooplankters were extremely scarce, fewer than 10 per liter. Occasional copepods and cladocerans were the principal forms collected. The effect of soil turbidity seemed to limit the zooplankton as well as the phytoplankton, which is a logical relationship, since phytoplankton forms the basis for the food chain upon which zooplankters are closely dependent. Claffey (1955) stated, "The same general pattern of distribution in the surface and bottom water found for the phytoplankters held true for the zooplankters."

The scarcity of plankton organisms in Heyburn Reservoir was probably caused by excessive turbidity and a low level of the inorganic elements essential to plant growth. Algae are probably the principal producers in lakes and are dependent upon the various inorganic elements and light. The nutritive elements must come from the watershed and the low alkaline quality of the soils in the Heyburn Reservoir watershed were reflected by the unusually low alkalinity readings of the lake water. That plankton is essential to the fish producing capacity of a lake is well known. Numerous investigators have studied the relationship between plankton production and the production of fish (Rounsefell and Everhart, 1953; Johnson, 1944; Wiebe, 1935; Surber and Olson, 1936; Smith and Swingle, 1938; Juday, 1924, 1943; and Surber, 1945).

Bottom Fauna

Bottom fauna organisms were relatively few in number ranging from six organisms per square foot of bottom sample in the deeper water to 45 per square-foot sample taken from the bottom of a cove in which considerable detritus was present (Table XX). The samples were collected with a Peterson dredge.

TABLE XX

Benthic organisms and numbers per square foot of bottom mud taken from deep and shallow areas in Heyburn Reservoir

Organism	No. of organisms below 20' deep	Organism	No. of organisms less than 10' deep
Diptera (midge larvae)	6	Diptera (midge larvae)	34
		Ephemerida (mayfly naiads)	6
		Odonata (damselfly naiads)	4
		Odonata (dragonfly naiad)	1
Total	6		45

Environmental conditions must not have been prime for bottom fauna organisms in Heyburn Reservoir. Wickliff and Roach (1937) believed that bottom fauna is apparently more dependent upon the nature of the soil of the bottom than on the age of the bottom. The role of bottom organisms in lake ecology has been considered by various investigators (Rawson, 1930, 1942; Eggleton, 1939; Moyle, 1946). Clark (1938) found bottom fauna to be scarce in Elephant Butte Reservoir and believed the scarcity to be the weakest link in the food chain.

Aquatic Vascular Plants

Aquatic vascular plants generally are considered important in determining the stability of a body of water. They serve as protection and, directly or indirectly, food for fish and other small animals that may be important in the food chain. Curran (1947) considered the abundance of aquatic vegetation in a lake to be dependent upon the quality and depth of the water and fertility of bottom soil. Heyburn Reservoir had a scarcity of aquatic plants, which suggests that at least one plant requirement was missing.

1. Submerged Plants

The submerged aquatic plants were virtually nonexistant in Heyburn Reservoir. In the most sheltered small back bays, where the water was not over a foot deep and relatively clear, occasional specimens of such forms as Potamogeton were present. The soil turbidity was of sufficient intensity to reduce light penetration to a point so low that photosynthesis could not take place; therefore, growth of plants was limited.

2. Emergent Plants

Emergent aquatic vegetation was also sparsely distributed around the lake. Along the west side of the Brown Creek Arm, midway of its length, an area of approximately half an acre of waterlilies, Nymphaceae, was established. According to a local resident, the area had been a farm pond prior to impoundment. Another and somewhat larger area of water lilies had become established on the upper Polecat Creek arm. Some of the bays, in the swampier areas, were bordered by small *Typha* marshes with such associated plants as *Sagittaria*, *Carex*, *Spartina*, and *Polygonum*. Much of the shoreline was abrupt and rocky, consequently unsuitable for aquatic plants.

DISCUSSION

Probably the most impressive information gained from the study was the unusually early decline of conditions, within the reservoir, which were essential to biological productivity. Following impoundment in 1950 Heyburn Reservoir remained clear through 1951 and the populations of fishes grew well. With the coming of spring rains in 1952, the runoff water, laden with silt and impoverished of inorganic nutritive substances, acted to reduce the electrolyte complex to such a low level that soil particles remained suspended resulting in high turbidity. Persistent turbidity was, thereafter, present in the reservoir throughout the study period and was believed to be a limiting factor to the production of aquatic organisms.

Through the various methods of sampling, a fish fauna of modest proportions was apparent. Specimens of twenty-five species were collected. White crappie, bullheads and miscellaneous small sunfishes were the most numerous species sought by the angling public. Channel catfish and large-mouth bass provided the major part of the sport fishery during the first three years of impoundment. Fishing pressure declined sharply with the rise of turbidity in the spring of 1952.

During the first two years of impoundment, when the water of the reservoir was clear, most game species made fairly good growth and were successful in reproduction, particularly in 1950. Most species spawned successfully in 1951 also, but this was generally a much weaker year-class than the preceding one. The spawning success of the fish population during 1952 and 1953 was drastically limited. Many of the nest-building scale fishes were particularly unsuccessful. The catfishes, mainly bullheads, seemed to be able to reproduce successfully in the presence of high turbidity. There appeared to be one exception to the slow growth of game species in Heyburn Reservoir; the flathead catfish seemed to have done exceptionally well. Age-growth data from a small sample indicated a growth rate that exceeded any reported from other Oklahoma waters.

The rough fish population appeared to develop slowly, a condition atypical to that reported from other reservoirs in the state. Carpsuckers were taken in greater numbers than any other species. It is possible that the preimpoundment population was of sufficient size to establish it as the most abundant rough-fish species in the early population of the reservoir. Reasons for the seemingly low carp population were not clear. Few were taken and reproduction appeared low; however, it is most likely that the species will become more numerous and probably occupy a major place in the rough fish population in the future. Though a few spotted gar were taken with rotenone it seemed doubtful that a population would develop because of the high turbidity of the water which should prove a handicap to their feeding.

Forage fishes were the most numerous in the reservoir, though not abundant in comparison to early populations of other reservoirs in the state. Gizzard shad was the most abundant fish in the reservoir and certainly the most abundant forage species. Unlike most game species, that enjoyed their greatest spawning success in 1950, shad reproduced more successfully in 1951 but were unable to make growths characteristic of the species in other waters. Phytoplankton, the principal food of shad, was unusually scarce in Heyburn Reservoir and its paucity was likely the reason for poor growth of the shad. Turbidity would have restricted photosynthesis and, therefore, operated to limit production of plankton.

It may then be assumed that edaphic factors influenced the biological conditions in Heyburn Reservoir. The watershed above the reservoir (127 square miles) represented a ratio, to the conservation pool, of about 76:1. This must be considered particularly large in an area where annual average rainfall is over 37 inches. The resulting large amounts of run-off water from a watershed characterized by rolling hills, deep gullies and thin, poor quality soils, could only contribute to such a process of succession as occurred in Heyburn Reservoir. There are no known, feasible management practices that could provide a sustained sports fishery on Heyburn Reservoir. Since the original productivity of the reservoir basin lasted approximately two years, it seems most unlikely that such a management practice as lowering the lake and growing crops of vegetation on the exposed bottoms would have an effect of sufficient proportion or duration to improve the fishing.

SUMMARY

1. The limnological aspects with emphasis placed on a study of the populations of fishes of Heyburn Reservoir, Creek County, Oklahoma are reported. The study involved was made during August and September, 1952 and June to August, 1953.

2. Description and characteristics are given of the reservoir (1070 surface acres) and of the comparatively large watershed which lies in a post oak, blackjack oak region of low fertility.

3. Samples of 25 species of fishes were collected during the summers of 1952 and 1953 using rotenone, wire traps, hoop nets, gill nets, tangle nets and seines. The selectivity and the efficiency of sampling methods are considered. Young-of-year (1953) largemouth bass and white crappie made poor growths and were extremely scarce. Though in modest numbers, the flathead catfish was the only species that seemed to be making good growth.

4. The age and growth calculations based upon scale and spine samples are reported.

5. Most species experienced greater spawning success in 1950, which was the first year of impoundment. In general, most year-classes exhibited faster growth in 1951 than in any other year. The lake became turbid in 1952 and the intensity of the turbidity was considered a limiting factor to productivity in the lake.

6. The populations of fishes in Heyburn Reservoir experienced mediocre success from the beginning, when compared with populations of

the other new lakes in the state. Factors of low level productivity in the environment of the lake and the watershed were believed to be responsible. The rough fish, carp, carpsuckers and shortnose gar were present in small numbers. Yearlings and young-of-year were notably few.

7. Readings of hydrogen-ion concentration, free carbon dioxide, alkalinity, water temperature and dissolved oxygen are reported from samples collected at various stations.

8. The depressing effects of soil turbidity upon the productivity of fish and fish food organisms in Heyburn Reservoir were pronounced.

9. Plankton and bottom fauna samples were collected periodically and the principal forms noted, but were found to be scarce.

10. Only occasional stands and a few dominant forms of aquatic plants were found.

11. Some considerations of productivity are discussed and an attempt made to compare various limnological conditions of a group of lakes with Heyburn Reservoir.

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